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A STUDY OF SUPERMANEUVER AERODYNAMICS

by

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An innovative method of examining fluid flow phenomena is described and preliminary results are given. The technique uses a subproblem formulation which examines only those portions of the flow which are of interest. The particular flow examined is that of a stalled airfoil and the objective of the technique is to develop ways of controlling the stall. Both conventional and nonconventional means of stall control have been examined and it is concluded that the subproblem technique is a viable approach for the study of fluid flow phenomena.

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Report AFOSR

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RESEARCH OBJECTIVES

The main objective of the work is to investigate the feasibility of an innovative method of understanding fluid flow phenomena. The method is based on a computational fluid dynamic (CFD) study of the flow. The idea is that interesting fluid flow phenomena can be examined by studying a "subproblem" that encompasses only the region of interest. Since the effect of the exterior flow or changes to the body is felt only through the impositions of boundary conditions any control device can be represented by some combination of boundary conditions. Since the mathematical theory of boundary conditions strictly limits the number of independent boundary conditions to much less than the number of possible control devices, a tractable parameter study can be formulated. Also, if the flow in the "subdomain" can only be affected by the boundary conditions a considerable insight into the causes of a particular flow phenomena can be acheived. The objective of the work is to test this idea for the flow over an oscillating airfoil at low speed, which can give dynamic stall.

STATUS OF THE RESEARCH EFFORT

After preliminary calculations it was decided that insufficient computer time was available for a study of dynamic stall and consequently a study of steady stall was initiated. The computer code ARC2D was used in the study. The airfoil is a NACA 0012 airfoil at $M_\infty = 0.3$ and 16 degrees angle of attack. The subproblem is the flow in a subdomain accompanying the seperated flow region of the airfoil.

In principle, the subproblem technique was validated. The validation process consisted of developing airfoil boundary conditions that would re-attach the flow on the airfoil and generally this objective was met by specifying a suction boundary condition on the airfoil surface. Initial and final pressure distributions and stream function contours for the subproblem are shown in Figures 1a, 1b and 2, respectively. To check the results, a complete airfoil calculation with suction was performed and the results, shown in Figure 3 confirm that the suction developed by the subproblem does, in fact, re-attach the flow.

An interesting variation on the suction boundary condition was the imposition of a normal velocity gradient boundary condition in the neighborhood of the separation point. This boundary condition produced a combination of suction and blowing that developed a vortex in this region that provided sufficient lift in the subdomain to compensate for the loss of lift due to the stall. Thus, a different way of alleviating stall may have been developed but further work is necessary before a definite conclusion can be reached.

Publications

Nixon, D. — A Study of Stall on an Airfoil
Farshchi, M. — Using a Subproblem Technique.
Neilsen Engineering Research
Paper No. 221, 1987

Professional Personnel

The work was performed by Dr. D. Nixon and Dr. Mohammad Farshchi.

No degrees were awarded as a result of the research.

Interactions

None.

New Discoveries

A new method of alleviating stall on an airfoil may have been developed but the results are not yet conclusive.

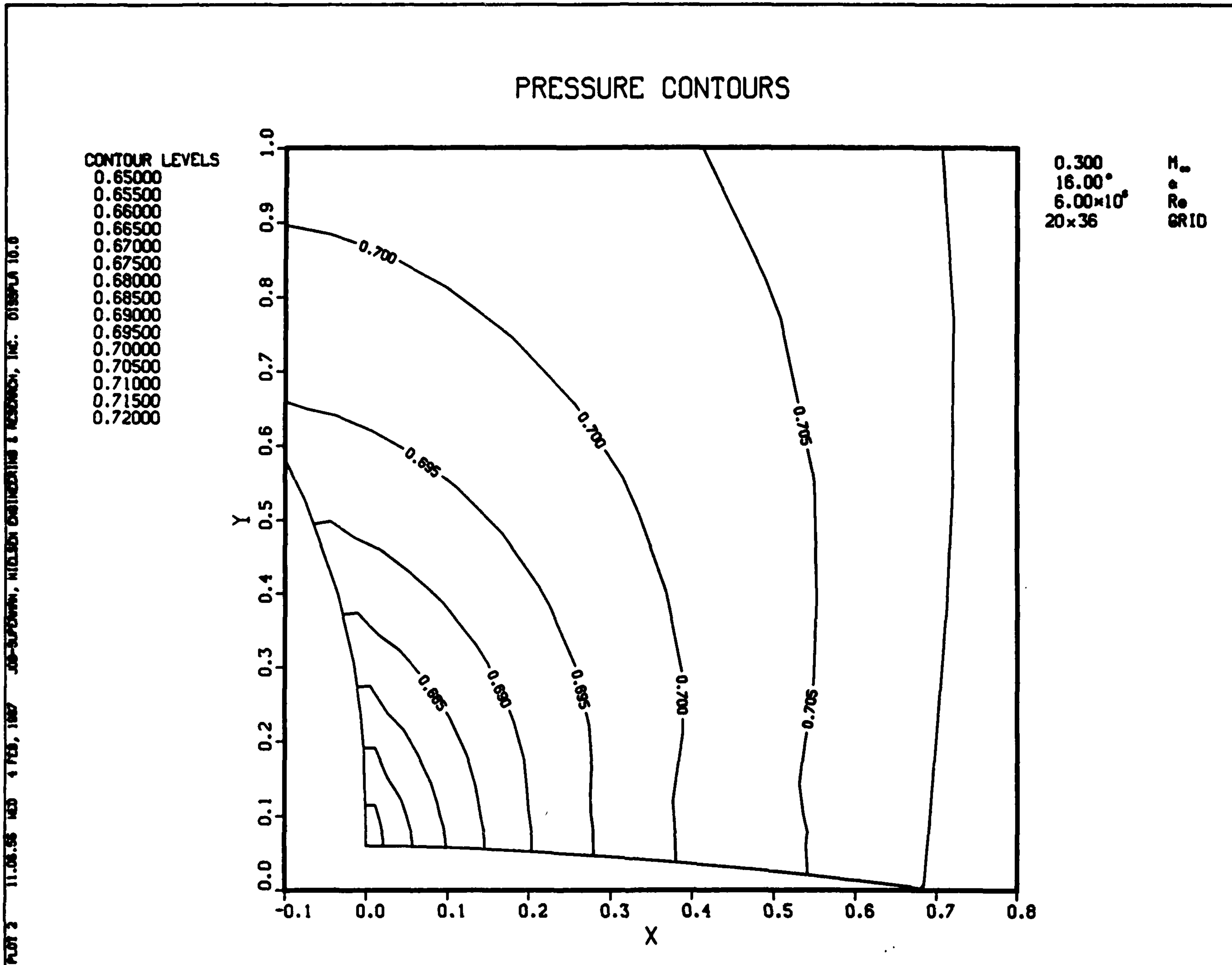

Figure 1a.- Pressure distribution from subproblem solution with inflow downstream boundary conditions.

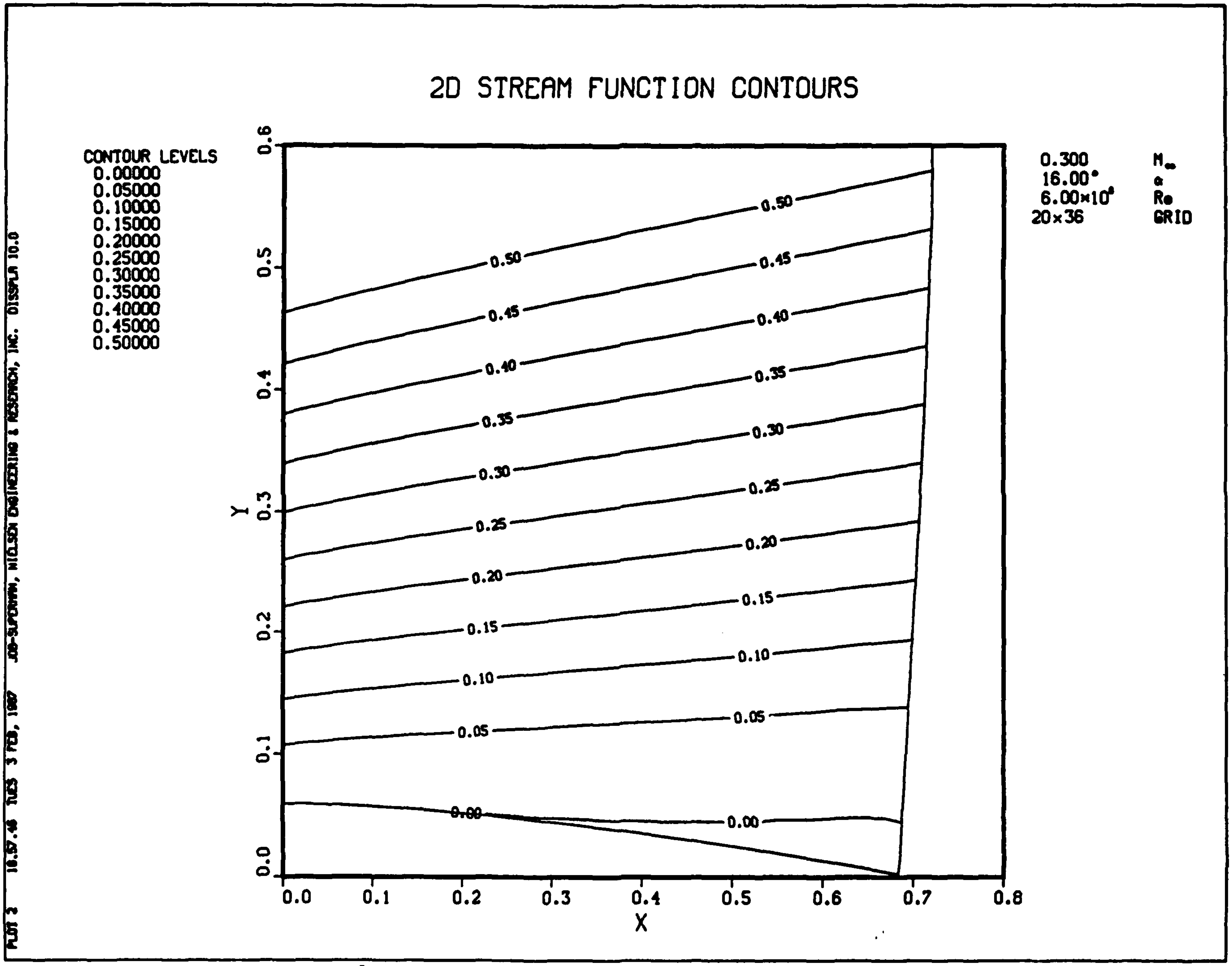

Figure 1b.- Streamlines from subproblem solution with inflow downstream boundary conditions.

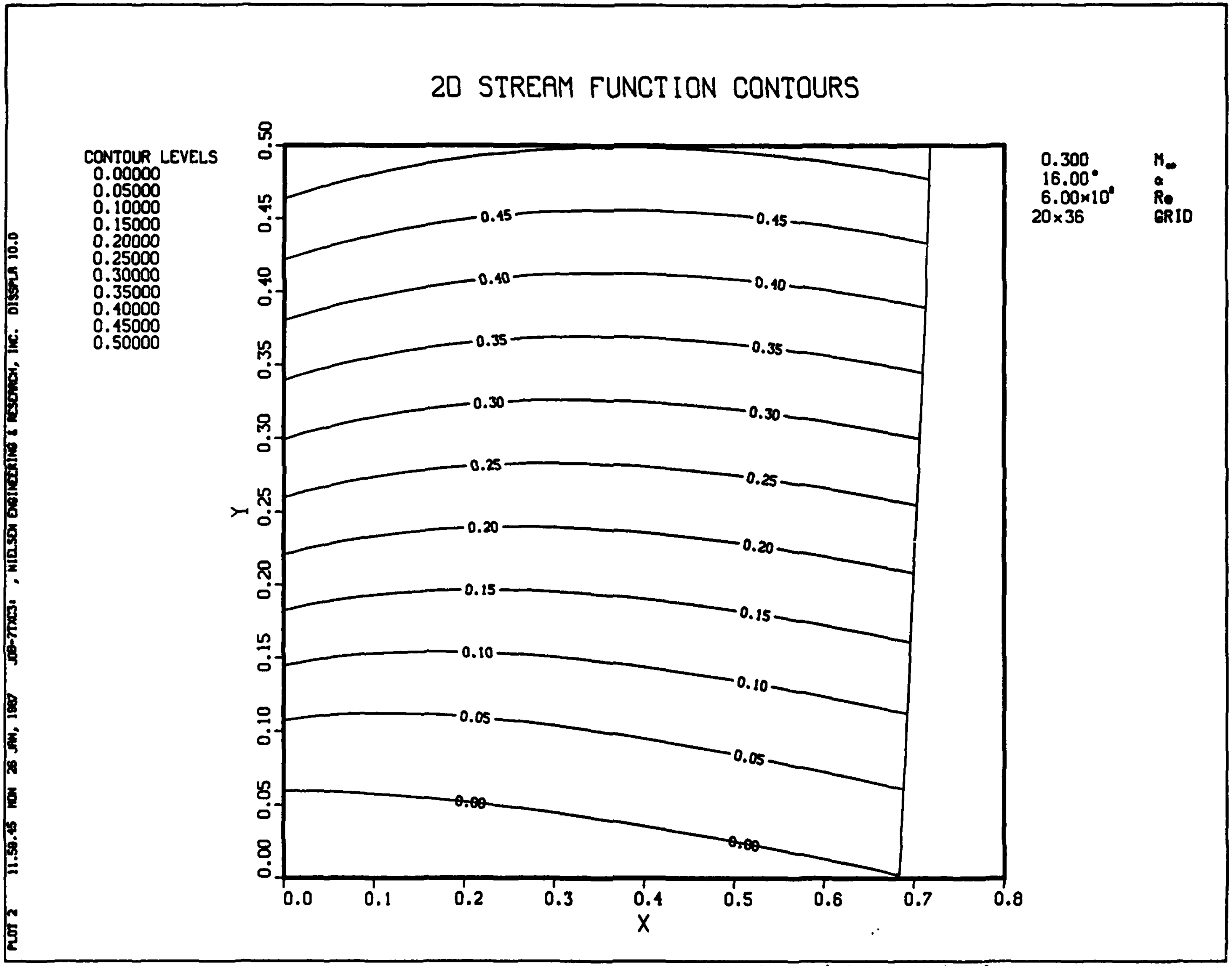

Figure 2.- Streamlines for a subproblem with K = -0.06 and modified out flow boundary conditions.

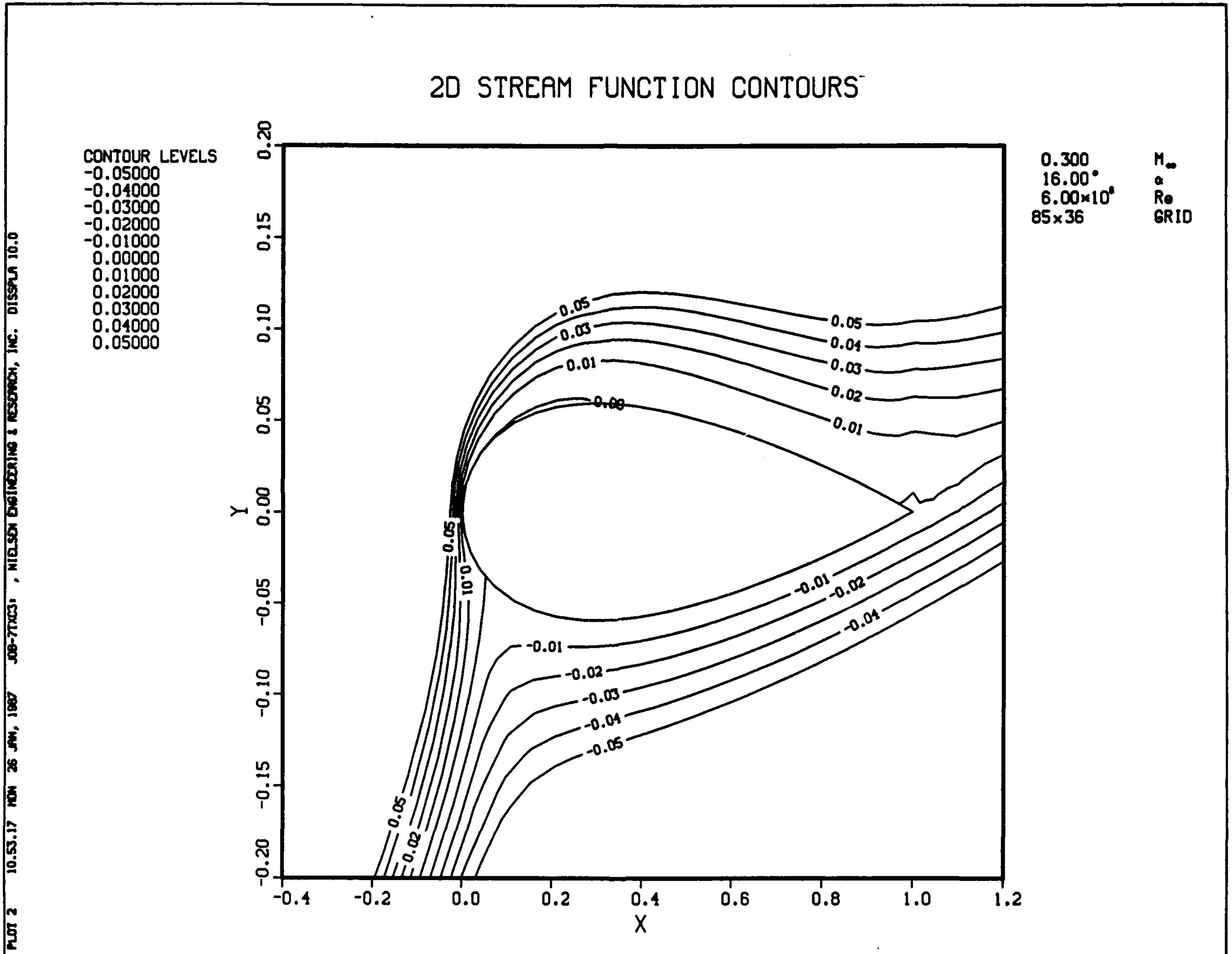

Figure 3.- Streamlines for complete airfoil solution
with suction just in subdomain region with K=-0.06.